I am an engineer in the Thermal Protections Systems group and I would like to talk to the media about the parts shown on the next page and how I work with them on a daily basis in my group. My presentation is not going to be very technical or identify materials/composition of the parts. I would like to use the sample TPS parts as visual aids.

Specifically, I will be stating the following:

When showing the HRSI tile, I would like to show the tile that is found on the lower surface of the orbiter and talk about the heating the HRSI tiles can take.

When showing the Ames gap filler, I would like to show that we install some gap fillers in between the tiles to prevent heating to the structure.

When showing the sample blanket, I would like to state the temperatures that the upper surface blankets can take.

When showing the waterproofing samples, I would like to demonstrate how one sample can absorb all the water when not waterproofed and show how the other sample does not absorb the water, but instead beads up on the surface. I will briefly talk about waterproofing and why we need it (e.g. rain out at the pad)

REPORT DOCUMENTATION PAGE

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14. ABSTRACT
Waterproofing tile demonstration utilizing an Ames gap filler, HRSI tile, sample thermal blanket and two tile samples.

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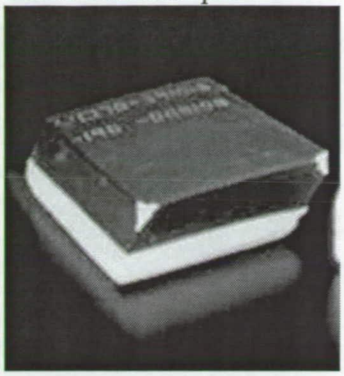
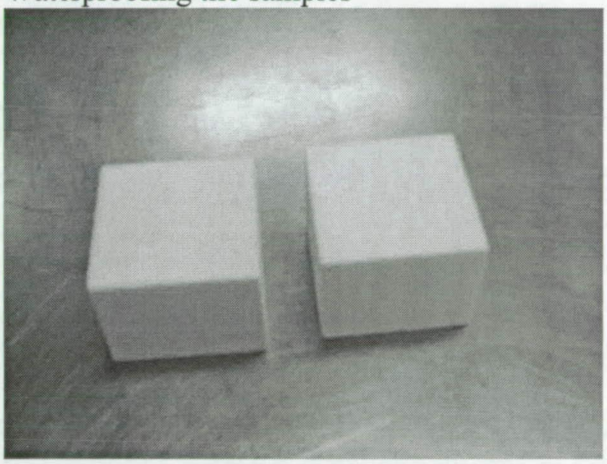
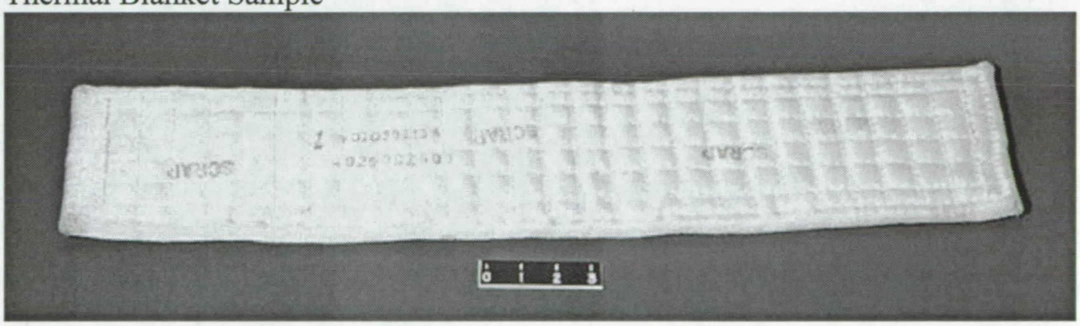
HRSI Tile Sample



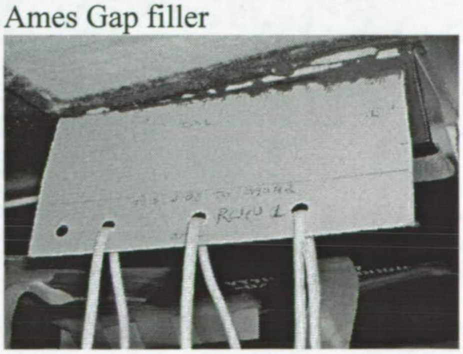
Waterproofing tile samples



Thermal Blanket Sample



Ames Gap filler



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ORBITER THERMAL PROTECTION SYSTEM

KSC Release No. 11-89
February 1989

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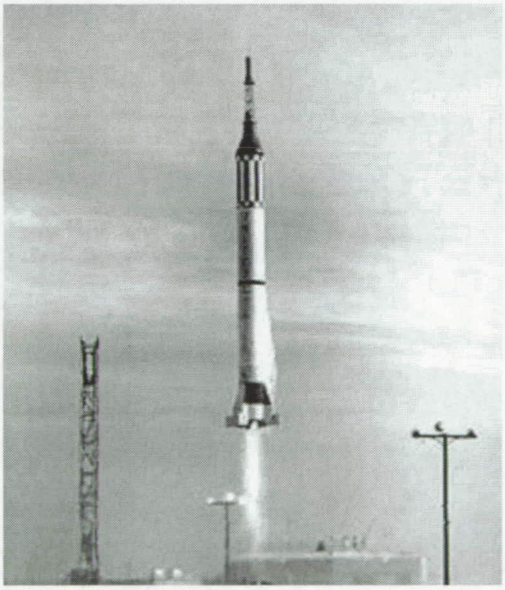
When a manned space vehicle re-enters the Earth's atmosphere, air friction can produce external surface temperatures as high as 3,000 degrees Fahrenheit - well above the melting point of steel. Special thermal barriers are required to protect the vehicle and its occupants.



Earlier manned spacecraft, such as Mercury, Gemini and Apollo, were not maneuverable and followed ballistic re- entry trajectories, parachuting to a watery landing in the ocean. The space capsules were protected during re-entry by shedding layers of a heavy, resinous heat shield through a process called ablation. The spacecraft were not reusable.

For the Space Shuttle orbiter, a different kind of heat protection system was needed. With a design life of about 100 missions, this revolutionary new space vehicle required a lightweight, reusable Thermal Protection System composed of entirely new materials.

NASA selected four basic materials for the original design used on Columbia, the first operational orbiter. Each was designed to insulate the orbiter's aluminum and/or graphite epoxy skin against a wide range of extreme temperatures, including a low of minus 250 degrees F. The basic materials were Reinforced Carbon-Carbon, Low- and High-Temperature Reusable Surface Insulation tiles, and Felt Reusable Surface Insulation blankets.

Subsequent design improvements included use of advanced materials in certain areas. These materials are Flexible Insulation Blankets and Fibrous Refractory Composite Insulation.

There are approximately 24,300 tiles and 2,300 Flexible Insulation Blankets on the outside of each orbiter.

The orbiter's nose cone, including the chin panel, and the leading edge of its wings are the hottest areas during re-entry. When maximum heating occurs about 20 minutes before touchdown, temperatures on these surfaces reach as high as 3,000 degrees F.

Reinforced Carbon-Carbon (RCC) is a light gray, all-carbon composite. RCC, along with inconel foil (metal) insulators and quartz blankets, protect the orbiter's nose, chin, and wing leading edges from the highest expected temperatures and aerodynamic forces. It also is used in the arrowhead area at the forward section of the orbiter where the external tank is attached. RCC is used there for shock protection during pyrotechnic separation of the external tank from the orbiter.

Fabrication of RCC begins with graphite cloth which is saturated with a special resin. Layers of the cloth are then laminated and cured, after which they are heat-treated to convert the resin into carbon.

After further processing, the material is treated with a mixture of alumina, silicon and silicon carbide to give it a grayish, oxidation-resistant coating, and then heated in a furnace. The orbiter's nose cap is fabricated as one piece while each of the wings has 22 seperate RCC panels and T- seals on the leading edge. Each panel is affixed to the orbiter's skin by mechanical attachments.

About 70 percent of an orbiter's external surface is shielded from heat by a network of more than 24,000 tiles formed from a silica fiber compound. More advanced materials such as Flexible Insulation Blankets have replaced tiles on some of the upper surfaces of the orbiter.

Coated black tiles-known as High-Temperature Reusable Surface Insulation (HRSI)-cover the lower surface of the orbiter, areas around the forward windows, upper body flap, the base heat shield, the "eyeballs" on the front of the Orbital Maneuvering System (OMS) pods, and the leading and trailing edges of the vertical stabilizer and the rudder speed brake. The black tiles are located where temperatures can reach as high as 2,300 degrees F.

Coated white tiles-known as Low-Temperature Reusable Surface Insulation (LRSI)-are designed to insulate the spacecraft from temperatures up to 1,200 degrees F. LRSI tiles were originally used extensively, but are now replaced in most areas by Flexible Insulation Blankets. LRSI is still used on the upper surface of the forward fuselage above the crew windows and on some parts of the OMS pods.

Tiles vary in size, thickness and density. HRSI tiles are generally 6 inches square; thickness varies from 1 to 5 inches. They come in different densities: 9- and 22-pound- per-cubic-foot tiles. LRSI tiles are larger and thinner, generally 8 inches square and from 0.2 to 1 inch thick. LRSI tiles come in 9- and 12-pound-per-cubic-foot densities.

The thermal properties of the tiles are dependent on their very high purity. The manufacture of both types of tiles begins with fibers of pure white silica refined from common sand. The fibers are mixed with deionized water and other chemicals and poured into a plastic mold where excess liquid is squeezed out of the mixture.

The damp blocks are dried in the nation's largest microwave oven at the Sunnyvale, Calif., plant of Lockheed Space Operations Co. Then, they are sintered in a 2,350 degrees F oven. Sintering fuses the fibers without melting them.

Rough cutting and precision sizing of the tiles are done with saws. Final shaping of the surface is accomplished with 3- and 5-axis numerically controlled milling machines using diamond-tipped cutters. The tiles are then spray-coated, glazed and waterproofed. The processing and inspection of each tile is documented, and individual tiles are traceable back to the orginal sand lots. No two tiles on an orbiter are exactly alike. The curvature of each tile's underside is matched to the contour of the Shuttle's skin at the exact point the tile is to be bonded.

The two types of tiles are the same except for their coating, which is primarily borosilicate glass. Chemicals are added to the coating to give the tiles different colors and heat rejection capabilities.

Surface heat dissipates so quickly that a tile can be held by its corners with a bare hand only seconds

after removal from a 2,300 degrees F oven, while the center of the tile still glows red with heat.

Improvements to the Thermal Protection System have reduced the amount of maintenance required after each mission. In many cases, scratches and gouges on the tiles can be repaired. A new assembly and manufacturing facility for thermal protection materials opened in 1988 at Kennedy Space Center. Two other tile assembly and manufacturing facilities are at Lockheed's Sunnyvale plant, and at Rockwell International's Palmdale, Calif., plant.

The tiles are delicate and have to be protected from the stresses on the orbiter's structure during flight. Launch blasts, aerodynamic pressures, steering forces, vibration and acceleration cause the vehicle body to bend and shift slightly during launch. In the cold soak of space, the vehicle shrinks slightly, only to expand again during re-entry.

To prevent damage to the tiles, Strain Isolation Pads - a layer of nylon felt Nomex (flame-retardant material)- are used between the tiles and the orbiter's surface. The pads are bonded to the tiles, as well as to the skin of the Shuttle, with RTV, a room-temperature vulcanizing silicone adhesive. The tile surface bonded to the pads is densified with silica-type solutions for added tensile strength.

Another type of protective blanket material is Felt Reusable Surface Insulation (FRSI) blankets. These blankets protect the orbiter surfaces from temperatures between 350 degrees and 700 degrees F. The insulation is coated with a white silicone rubber paint. FRSI once covered about 25 percent of the vehicle. Now, the material is used only on the upper section of the payload bay doors and the inboard sections of the wing upper surface.

Most of the LRSI tiles and FRSI blankets have been replaced by Flexible Insulation Blankets (FIBs), composed of a waterproofed, quilted fabric with silica felt between two layers of glass cloth sewn together with silica thread. The average FIB weighs 4.9 kilograms or 11 pounds per cubic foot.

The blankets have better durability, and cost less to make and install than the tiles. They are used on the upper sidewalls of the orbiter's fuselage, sections of the payload bay doors, most of the vertical stabilizer and rudder speed brake areas, the outboard and aft sections of the upper wing, parts of the elevons, and around the observation windows.

Some of the HRSI tiles have been replaced by Fibrous Refractory Composite Insulation (FRCI-12), which are less dense than the 22-pound-per-cubic- foot HRSI tiles but comparable in strength. They are used around penetrations and leading edge areas.

Other thermal materials used are the filler bar and gap fillers which seal gaps between tiles and between the tiles and the orbiter structure. The seals protect the aluminum and/or graphite epoxy skin of the orbiter by preventing the influx of hot plasma gas. The gap fillers are envelopes of ceramic fiber cloth stuffed with a resilient ceramic filler batt, and sometimes with a metal foil. The filler bar consists of strips of Nomex felt coated with RTV, and is part of the assembly method used for tiles.

A combination of white and black pigmented silica cloth make up thermal barriers, and are installed around penetrable areas such as main and nose landing gear doors, the orbiter's side hatch, umbilical doors, elevons, forward Reaction Control System module and thrusters, OMS pods, and gaps between tiles in high differential pressure areas.

Fused silica is used for the outer windows in the orbiter. Metal is used for the forward reaction control system fairings and elevon seal panels on the upper wing elevon interface.

All of the major ingredients in the Shuttle's external Thermal Protection System-tiles, Flexible Insulation Blankets and Felt Reusable Surface Insulation-are bonded to the orbiter with the RTV adhesive. The cement will withstand temperatures as high as 550 degrees F, and as low as minus 250 degrees F without losing its bond strength.

After each flight, the orbiter's external Thermal Protection System is rewaterproofed. Dimethylethoxysilane is injected into the tiles through an existing hole in the surface coating with a needleless gun, and the blankets are injected by a needle gun. The procedure must be done each time because the waterproofing material burns out at 1,100 degrees F., thus exposing the outer surface of the thermal system to water absorption.

There are numerous and far-ranging possibilities for spinoffs or commercial applications of Thermal Protection System materials. For example, tiles can be ideal as a jeweler's soldering base because they absorb so little heat from a torch, do not contaminate precious metals and are soft enough to hold items to be soldered. Because of their purity, tiles can be an excellent high-temperature filter for liquid metals. Carbon-carbon pistons have been shown to be lighter than aluminum pistons and increase the mechanical and thermal efficiencies of internal combustion engines.

High costs at this time are a deterrent to widespread application of the techniques and materials of the Thermal Protection System. A single coated tile can cost as much as $2,000. But technological advances may make these pure, lightweight thermal materials the new insulators of the future.

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